SOIL POLLUTION FROM VEHICULAR LEAD EMISSION IN ENUGU SOUTH LOCAL GOVERNMENT AREA OF ENUGU STATE, NIGERIA

Eze, H. I.
Centre for Environmental Management and Control (CEMAC)
University of Nigeria, Enugu Campus
E-mail: *hileze@yahoo.com*

ABSTRACT

A study on the pollution of soil from lead contaminants in vehicular exhaust emission in the Enugu South Local Government Area of Enugu State, Nigeria has been carried out. Twenty one experimental and control sites were involved. Laboratory chemical analysis using the spectrophotometer was employed in the detection of lead toxicity level in the soil samples. The soil sample leads pollution index and the Analysis of variance statistics were used to analyse the laboratory results which proved that the experimental sites have very high lead contamination than the control site. The hazardous effects of leads were addressed to create awareness of this toxic substance. The advanced recommended measures should be seriously adhered to with a view to reducing health deteriorating problems that arise from both acute and chronic exposure to lead.
Keywords: *Pollution, Lead, Emission, Environment, Sustainability*

INTRODUCTION

Lead, whose chemical symbol is pb is a metallic element. It is heavy, dully grey, soft and ductile. Lead falls into Group 14 (formerly IVB) of the Periodic Table of Elements. With an atomic number of 82 and melting point of 327.5^{o}C, its boiling point shoots up to 1740^{o}C (Ababio, 2005). The dominant proportion of lead in air emanates from the combustion of Premium Motor Spirit (petrol). The main constituent of this combustion process is lead tetrachloride with many other lead compounds as trace constituents. The environment, especially, soil close to the highways is highly polluted and degraded by lead in inorganic forms. The various uses of lead include building materials, lead-plate accumulators, bullets, shots and weights, constituents of alloys solder, pewter, bearing metals, type metal and fusible alloys. This makes it possible to also contaminate the environment (Daintith, 2000).

The United States Environmental Protection Agency (USEPA, 2010b) observed that lead is toxic. It can get into drinking water through plumbing materials. Ian (2001) and Kallman (2008) remark that lead particulates in air find the soil as their final destination through settlement under gravity, causing environmental pollution. Environmental pollution is generally defined as the injection of harmful contaminants such as chemicals or energy into the environment (air, land and water) to such an extent that the natural self-purifying mechanism can no longer cope with. It then starts causing instability, discomfort, harm, disorder to biological and non-living things. Wikipedia (2010c), Eneh (2010) and USEPA (2009) hold the same

view of this definition. Air pollutants include lead, dust, carbon monoxide, carbon dioxide, aerosols, ground level ozone, hydrochlorofluorocarbons (HCFCs), and oxides of Nitrogen (NOx), oxides of sulfur (SOx), radiation, propellants mercury, refrigerants and fungal spores. Water pollutants are industrial effluent discharges, air pollutants from acid rain, solid wastes washed into water bodies by runoff water and leachets. Soil pollutants are toxic chemical wastes released from air pollution that settle on the soil either by gravity or acid rain, chemical spills, underground leakages, landfill waste leachets and war explosives.

The industrial revolution and the enormous fuel powering of its activities started the spewing of lead contaminated fume and smog. In 1952 the Great Smog of London killed about 4000 people brought about promulgation of the Clean Air Act of 1956 (USEPA, 2003 and Wikipedia, 2010c). Lead is also released in alarming quantities from gas flaring. When lead is emitted into the serene environment it reacts with oxygen (O_2) to form lead oxide. When in contact with water vapour in the environment, it forms lead (II) hydroxide and with carbon dioxide it forms lead (II) tri oxocarbonate (Ababio, 2005). These can be chemically expressed thus:

$$2Pb(s) + O_{2(g)} = 2PbO(s)$$

$$2Pb(s) + 4H_2O_{(aq)} = 2Pb(OH)_{2(s)} + 4H^+$$

$$2Pb(s) + 4CO_{2(g)} = 2PbCO_{3(s)} + 2CO_{(g)}$$

When subjected to severe heating such as in refuse incineration it can reverse to lead (II) oxide or red dilead(II) lead (Iv) oxide. This can also be expressed as:

$$3Pb(s) \times 2O_{2(g)} = Pb3O_{4(s)}$$

METHODOLOGY

Enugu-South Local Government Area is the study location. The area is in the southern zone of the Enugu coal city. It is bounded on the North by Enugu North LGA and on the South, East and West by Nkanu West LGA. Enugu South LGA comprises of Uwani, Achara Layout, Idaw River, Awkunanaw, New Era and Mary- Land Layouts. It lies within latitudes 6°21'N and 6°30'N of the equator and longitudes 7°36E and 7°36'E of the Greenwich Meridian. The population is 198,723 (2006 National Population Census). The climate is the Koppen's wet and dry (Aw type) climate classification. It has a rainy spell from April to October and dry period from November to March. The average temperature is 27°C. Its vegetation is the derived guinea savannah wood land. The topography is undulating and drained by many streams and rivulets that spring from the Udi Hill which is 457m above sea level. Enugu South LGA falls within the Cross River Basin and Benue Trough. A great deal of this area has been ravaged by sheet and gully erosion (Egboka, 1985).

Complete randomized sampling Technique was employed to select some roads and streets as study locations. The traffic on these roads and streets are higher in the morning hours of school runs and movement of people to work places, in the afternoon period of school run, finally in the evenings at close of work and business activities. Unpaved and undeveloped land plot areas that are not more than 1.5 to 2.5m from

the roads or streets were taken as experimental locations while the far end of the plots of land of about 30m away from the roads were used as control locations. Disused casserole plates were used to scoop soil from depths of 3-7cm into prelabelled plastic bags. Two specimens were collected from each sampling locations to get a mean after laboratory tests.

Each soil sample was air-dried in a well ventilated chemistry laboratory for one week. Pieces of glass, metal, plastic and other materials in the soil sample were removed. The soil was crumbled and crushed into finer state. There- after a sieve shaker was used to shake and sieve 3-5g of the sample through sieve size or aperture of 1.5cm or 1.7cm. Then, the sample was digested with 30ml of 1M (one mole) of Nitric Acid (HNO_3). It was subjected to heating at 150-160^oC. This process was continued until the fumes coming out of the sample became clear. Distilled water was added into the sample after digestion. On cooling, the samples were each filtered into a volumetric flask. It was then diluted it up to 40-50ml. Then the samples were washed with distilled water and oven dried. An Inductively Coupled Plasma Atomic Emission Sepectrophotometer (ICP-AES) was used to analyse for lead detection at the standard wave length. This remote sensing gadget has unmatched resolution capabilities to read the concentration of any element in any composite material. The emitted rays impinge on scales where the leads concentrations in the soil samples were read off. Sanka et al (1995) advanced soil pollution index threshold value for lead as 50mg/kg. Then, to compute the soil lead pollution index for the soil samples, the following expression was employed.

Soil lead pollution index $$SLPI = \frac{Lead\ \ Conta\min ation\ \ Level\ \ soil}{Soil\ Lead\ \ Threshold\ \ Value} \times \frac{100}{1}$$

The values of laboratory tests for both experimental and control soil samples were subjected to the Analysis of Variance Statistical method to find out the degree of variations between the two locations. The results are presented on tables.

RESULTS AND DISCUSSION

The values of the lead contamination level in the soil samples are as seen on table 1. The environmental lead contamination levels in the experimental soil samples range from 36.8 - 246.3mg/kg. From the Sanka et al (1995) threshold value for soil lead contamination, it can be deduced that the soils of the control sampling locations do not meet this level and as such are pollution free. However, the experimental locations are highly polluted.

Lead is added to all forms of combustion fluids such as petrol, diesel, aviation fuel and kerosene. The paramount reason for the addition of lead to these fuel types is to increase their octane values. This simply means to make them attain efficient combustion. Petrol which is known as Premium Motor Spirit (PMS) is the commonest and widely used among these fluids. The fallout of lead from the exhaust pipes of

moving cars and trucks pollute the soil near to the highways. Children who play around homes near busy roads or street ingest soil containing lead. This is hazardous. It increases their blood lead level and impairs the development of their brain and nervous system. This decreases their intelligence quotience by about 25 percent. Lead in blood also militates on the biochemical functions of the kidney and blood formation by the borne marrows.

Akubue (1997) opines that adult exposure to lead is a result of industrial activities such as mining, smelting, refining and manufacturing processes. This reduces their productivity when symptoms such as loss of appetite, nausea, vomiting, stomach cramps, constipation, insomnia, fatigue, moodiness, headache, joint and muscle ache, anemia and decreased sexual drive manifest. Uncontrolled occupational exposure results in fatalities and severe damage to blood forming nervous urinary and reproductive systems. These hazardous effects are from both chronic (long term) and acute (short term) exposures to lead.

ATSDR (2007) has made a glossary of the soil environmental effects from the toxic substances of which lead is inclusive. They investigated that lead poisoning are mainly from automobile and industrial generator fumes. This causes anorexia, hallucination, restlessness, irritability with hypothermia and hypotension especially when exposed to tetraethyl-lead and tetramethyl-lead (Akubue, 1997). Fodders growing on lead contaminated soils absorb them. When these fodders are consumed by livestocks, the contaminants bi-accumulate in them. The Fcal is 62.47 and is greater than $F_{cal}\ \alpha$ 4.08. Hence there is a significant variation or difference between lead toxicity in the samples of the experimental and control location samples of the study areas. The levels of the experimental locations are higher.

Table 1: Toxicity Level of lead in Soil Samples from the Study Locations

S/no	Study Location	Layout or settlement	Toxic Level of lead (mg/kg)	
			Experimental Location	Control Location
1	Edozien Street	Uwani	120.4	9.0
2	Ngwo Street	Uwani	43.2	9.15
3	Robinson Street	Uwani	97.6	9.25
4	Adelabu Street	Uwani	50.2	9.06
5	Zik's Avenue	Uwani	203.5	9.3
6	Peter Okoye Street	Uwani	63.8	9.05
7	Nise Street	Uwani	71.4	9.02
8	Achina Street	Idaw River	85.0	9.52
9	Awkunanaw Street	Achara	90.8	9.38
10	Akpo Street	Achara	67.1	9.0
11	Igbariam Street	Achara	65.1	9.01
12	Osumenyi Street	Achara	69.8	9.0
13	Akwueke Road	Gariki	81.4	9.1
14	Ebony Paint Road	Gariki	93.5	9.31
15	Enugu-PH Xpress Rd	Ugwuaji/Amechi	259.7	9.7
16	Ugwuaji Rd	Maryland	209.1	9.6
17	Amechi Rd	Topland	181.0	9.22
18	Obeagu Rd	Gariki	103.6	9.14
19	One Day Rd	Gariki	95.3	4.21
20	Meniru Street	Awkunanaw	77.4	9.0
21	Agbani Rd	Uwani/Awkunanaw	246.3	9.5

While that of control sampling locations was 9.0 - 9.7mg/kg.

Table 2: Soil Lead Pollution Indices for the Study Locations

S/no	Study Location	Toxic Level of lead (mg/kg)	
		Experimental Location	Control Location
1	Edozien Street	240.8	18.0
2	Ngwo Street	86.4	18.30
3	Robinson Street	195.2	18.50
4	Adelabu Street	100.4	18.12
5	Zik's Avenue	407.0	18.6
6	Peter Okoye Street	73.6	18.10
7	Nise Street	142.8	18.04
8	Achina Street	170.0	19.04
9	Awkunanaw Street	181.6	19.76
10	Akpo Street	134.2	18.76
11	Igbariam Street	130.2	18.0
12	Osumenyi Street	139.6	18.02
13	Akwueke Road	162.8	18.0
14	Ebony Paint Road	187.0	18.62
15	Enugu-PH Xpress Rd	519.4	19.4
16	Ugwuaji Rd	418.2	19.2
17	Amechi Rd	262.0	18.44
18	Obeagu Rd	207.2	18.28
19	One Day Rd	190.6	18.42
20	Meniru Street	154.8	18.0
21	Agbani Rd	492.6	19.0

Table 3: ANOVA Table for Toxicity Level for Soil Samples from Study Locations

S/no	Study Location	Toxic Level of lead (mg/kg)	
		Experimental Location	Control Location
1	Edozien Street	120.4	9.0
2	Ngwo Street	43.2	9.15
3	Robinson Street	97.6	9.25
4	Adelabu Street	50.2	9.06
5	Zik's Avenue	203.5	9.3
6	Peter Okoye Street	63.8	9.05
7	Nise Street	71.4	9.02
8	Achina Street	85.0	9.52
9	Awkunanaw Street	90.8	9.38
10	Akpo Street	67.1	9.0
11	Igbariam Street	65.1	9.01
12	Osumenyi Street	69.8	9.0
13	Akwueke Road	81.4	9.1
14	Ebony Paint Road	93.5	9.31
15	Enugu-PH Xpress Rd	259.7	9.7
16	Ugwuaji Rd	209.1	9.6
17	Amechi Rd	181.0	9.22
18	Obeagu Rd	103.6	9.14
19	One Day Rd	95.3	4.21
20	Meniru Street	77.4	9.0
21	Agbani Rd	246.3	9.5
		2348.2	193.52

.....2

$$\bar{x} = \frac{2348.2;\ 193.52}{21 \quad 21}$$

$$\bar{x} = 11.82;\ 9.22$$

Grand mean, $\bar{\bar{x}} = \frac{\sum xj}{\sum Nj}$ 3

$$\bar{\bar{x}} = \frac{111.82 + 9.22}{21 \ + \ 21} \ = \ 2.88$$

To compute the sum of squares within:

$$SSw \ = \ \sum\left[\sum(xi) - \bar{x}^2\right] \qquad \text{..... 4}$$

Table 4: Experimental Sample

S/N	X_{ij}	$X_{ij} - X_1$	$(X_{ij} - X_1)^2$
1	120.4	8.58	73.62
2	43.2	-68.62	4708.7
3	97.6	-14.22	202.21
4	50.2	-61.62	8405.22
5	203.5	91.68	3242.16
6	63.8	-56.94	1633.78
7	71.4	-40.42	719.31
8	85.0	-26.82	1441.84
9	90.8	-21.02	1999.88
10	67.1	-44.72	4188.68
11	65.1	-64.72	1765.68
12	69.8	-42.02	925.38
13	81.4	-30.42	335.62
14	93.5	-18.32	21868.5
15	259.7	147.88	9463.4
16	209.1	97.28	4785.87
17	181.0	69.18	67.57
18	103.6	-8.22	9463.2
19	95.3	-16.52	272.91
20	77.4	-34.42	1184.74
21	246.3	134.48	18084.87
	$\sum = 2348.2$		
	$\bar{x} = 111.92$	$\sum = 89932.64$	

Table 4 Control Sample

S/N	X_{ij}	$X_{ij} - X_1$	$(X_{ij} - X_1)^2$
1	9.0	-0.22	0.048
2	9.15	-0.07	0.0049
3	9.25	0.03	0.0009
4	9.06	-0.16	0.256
5	9.3	0.08	0.0064
6	9.05	-0.17	0.0289
7	9.02	-0.2	0.04
8	9.52	0.3	0.09
9	9.38	0.16	0.026
10	9.0	-0.22	0.0484
11	9.01	-0.21	0.044
12	9.0	-0.22	0.0484
13	9.1	-0.12	0.0144
14	9.31	0.09	0.0081
15	9.7	0.48	0.2304
16	9.6	0.38	0.1444
17	9.22	0.0	0.0
18	9.14	0.08	0.0064
19	4.21	-0.01	0.0001
20	9.0	-0.22	0.0484
21	9.5	0.28	0.0784
	$\sum = 193.52$		
	$\bar{x} = 9.22$	$\sum = 1.6372$	

The sample mean, $\bar{x} = \frac{\sum xij}{Nj}$

$$SSw \quad = \quad \sum[\sum(x_{ij} - \bar{x}_j)^2]$$

$$= \quad 89932.64 + 1.6372 = 89934.28$$

To find the sum of squares between, SSb

$$SSb \quad = \quad \sum[n_j(\bar{\bar{x}} - \bar{x})^2] \qquad \text{.....(5)}$$

$$= \quad [21(111.82 - 2.83)^2 + 21\ (9.22 - 2.88)^2] = 250070.43$$

To compute the Error = SSw - SSb ..... (6)

= 89934.28 -250070.43 = -160136.15

Mean of square error = Error ÷ (N - n)

= -160136.15 (42-2)

= -4003.40

Mean of squares = SSb (n-1)

= 250060.43 (2-1)

= 250060.43

F- ratio = Mean of squares mean of squares error

= 250060.43 4003.40

= 62.47

CONCLUSION AND RECOMMENDATIONS

Lead has been identified and certified as a lethal environmental substance. Environmental management is centrally concerned with sustainability. Sustainability is all about non-compromise of the environment and its resources with socio-economic activities. Proffering of substitutes to lead; modification of processing/equipment, greening of children's play grounds, adherence to industrial safety, minimization of workers to lead among others are sustainability practices. These will allow transportation, use of power generators, industrial activities as well as other human activities without jeopardizing environmental human well being. A well articulated engineering control system should be programmed for the minimization of exposure of workers to lead. Very sensitive radar or lead dictating devices should be employed in the checking of lead concentration levels that are in contact with workers in industries.

Regular short-term training of workers on health, safety and environment as well as good working practices will enhance occupational safety and broaden their insight in awareness of hazardous substances in work places. Protective acutruments such as head gears, boots, aprons that shield the skin from lead dust, nose and mouth muffs, ear muffs and goggles will reduce the risk and disaster from lead contamination. In prolonged work operations where lead dust or petroleum combustion smug is in evitable, good respirators should be used to prevent lead contaminated smoke inhalation. The employment of the services of competent chemists as consultants will be useful in the suggestion of chemical substitute to lead in manufacturing industries as well as petroleum refineries. This can reduce environmental/soil lead pollution and this is sustainability in its practical form. Grassing of home premises near the road would reduce the risks of children ingesting soil contaminated with lead. Livestock should not be allowed to graze near roads nor the fodder collected from such places.

Consignment of lead in industries or refineries should be isolated. They should be kept safely under lock and key at a far corner of the industrial yard. Production and industrial engineers should improve in the modification of processing operations

and manufacturing equipment to enhance the safety of workers from lead exposure. This modification would be also applied in the mix design of lead in combustion fuel. Industrial halls where lead processing takes place should be properly ventilated for the safety of the operatives. There should be normal level windows and permanently open high level windows for uninterrupted escape of lead particulates. Personal hygiene practices are a safety factors. The equipment in the industry should be periodically inspected and maintained. There should be appropriate supervision to ensure proper procedural operation.

REFERENCES

Ababio, O. Y. (2005). *New School Chemistry for Senior Secondary Schools* (3rd ed.) Onitsha: Africana First Publication Ltd.

Akubue, P. I. (1997). *Piosons in our Environment and Drug Overdose: A Guide for Health Professional and the Lay Public.* Enugu: Snaap Publication.

ATSDR (2007). Public Health Statement for Lead. Agency for Toxic Substances and Disease Registry of the US August 20.

Daintith, J. (ed) (2000). *A Dictionary of Chemistry* (4th ed.). Oxford: University Press.

Egboka, B. C. E. (1985). Water Resource Problems in the Enugu Areas of Anambra State, Nigeria. Water Resources and Environmental Pollution Unit (WREPU).

Ene, O. C. (2010). Green Chemistry: Studies on Recycling Hazardous Chemical Components of the E-Waste Hems in Africa. Unpublished Ph.D Seminar Paper submitted to Centre for Environmental Management and Control, University of Nigeria, Enugu Campus.

Ian, W. (2001). *Environmental Chemistry: A Molecular Approach.* New York: John Wiley & Sons.

Kallman, M. (2008). Air Pollution's Causes, Consequences and Solutions. World Resources Institute: Aug 2008 Monthly Update.

National Population Commission (NPC) (2006). *National and State Population Tables. Priority Tables Vol 1*. Abuja: National Population Commission.

Sanka M., Strnad M., Vondara J. and Paterson E. (1995). Sources of Soil and Plant Contamination in an Urban Environment and Possible Assessment Methods. *International Journal of Environment and Chemicals,* 59, 327-343.

USEPA (United States Environmental Protection Agency) (2003). Protecting Water Quality from Agricultural Runoff. Document no EPA 841-F-03-003 Washington, DC: USEPA.

USEPA (United States Environmental Protection Agency) (2009). Air Pollutants. Retrieved on 7/21/2009 from *http://www.epa.gov/air/airpollutants.hmtl.*

USEPA (United States Environmental Protection Agency) (2010b). Facts about Lead. Retrieved on 7/29/2010 from *http://ww.epa.gov/lead/pubs/leadinfo.htm#hazard.*

Wikipedia, the Encyclopedia (2010c). Pollution Retrieved on 7/2/2010 from *http://en.wikipedia.org/wiki/pollution.*